SPECIAL ARTICLE

THE PREVALENCE OF CANCER

Estimates Based on the Connecticut Tumor Registry

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Abstract Cancer incidence and mortality do not fully reflect the effect of cancer. To estimate the number of persons alive who have a history of cancer, we derived prevalence rates based on data from the Connecticut Tumor Registry. We did not attempt to distinguish between people who had been cured of cancer and those who still had the disease. In 1982 the age-adjusted prevalence rates of cancer among males and females were 1789 and 2222, respectively, per 100,000. Age-specific prevalence rates were highest among the elderly; 12 percent of men and 11 percent of women over 70 had previously been given a diagnosis of cancer. Breast cancer in females and prostate cancer in males were the two most prevalent malignant diseases. We estimate that about 5 million persons alive in the United States today have at one time received a diagnosis of cancer. (N Engl J Med 1986; 315:1394-7.)

MORE people who have had a diagnosis of cancer are alive today than ever before.[1] Although it is known that the number of living patients with cancer is increasing for a variety of reasons, including progress in the treatment of cancer,[2] technological advances that result in earlier diagnoses,[3] and the growing and aging of the U.S. population, there is no substantiated estimate of the magnitude of this number. An understanding of the extent of morbidity due to cancer in the U.S. population would serve to underscore the necessity of incorporating cancer prevention into the practice of medicine and of heightening physician awareness of the needs of a large number of persons who are coping with the physical, social, and emotional sequelae of cancer.

This paper presents estimates of cancer prevalence derived from the Connecticut Tumor Registry, the oldest population-based tumor registry in the country. This registry, which has existed since 1935, has been used as an outstanding source of incidence and survival data, as well as a source for planning cancer control programs and etiologic studies of disease.[4] The long history of the registry, along with its extensive patient follow-up system, presented the opportunity to document the prevalence of cancer in a population in the United States.

METHODS

Case Selection

This investigation was based on data submitted to the Surveillance, Epidemiology, and End Results (SEER) program of the National Cancer Institute by the Connecticut Tumor Registry. The data included all cases of cancer (except basal- and squamous-cell cancer of the skin) diagnosed from 1935 through 1981. Follow-up status into 1983 was recorded as the date on which the patient was last known to be alive or to have died. Standard follow-up procedures undertaken by the registry have been documented elsewhere.[4]

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We defined "prevalent cases" as those in which persons alive on January 1, 1982, had been given a diagnosis of invasive cancer between January 1, 1935, and December 31, 1981. There were 288,221 residents of Connecticut who had received a diagnosis of cancer in that period, of whom 53,628 (18.6 percent) were known to be living on January 1, 1982 ("known prevalent cases"), and 214,712 (74.5 percent) had died before January 1, 1982. The remaining 19,881 (6.9 percent) were lost to follow-up but had been reported to have been alive at the date of last contact before January 1, 1982. Using the methods described below, we estimated that 72.7 percent of the patients lost to follow-up were alive on January 1, 1982 ("estimated prevalent cases").

Calculation of Prevalence

For each site of cancer and each sex, we computed the age on January 1, 1982, of the persons with either known or estimated prevalent cases. For each five-year age group, the number of known prevalent cases was added to the number of estimated prevalent cases. Prevalence rates were calculated by dividing these sums by the appropriate populations in Connecticut on January 1, 1982 (derived from U.S. Census Bureau data for 1970 and 1980).

The life-table method[5] was used to estimate the number of patients among those lost to follow-up who would have survived until January 1, 1982. To account for changes in survival over time, four cohorts of cases, divided according to year of cancer diagnosis (1935–1949, 1950–1959, 1960–1969, and 1970–1981), were used to generate annual survival probabilities for each cancer site and sex. For each cancer case lost to follow-up, the probability of surviving to January 1, 1982, was calculated as conditional on both the year of diagnosis and the year of loss to follow-up. This probability, denoted CP, can be written as follows:

$$CP = \sqrt{P_i} \times P_{i+1} \times P_{i+2} \times \cdots \times P_{j-1} \times P_j,$$

where P_i is the observed survival probability for the first year during which the patient was lost to follow-up, and $P_{i+1}, \ldots, P_{j-1}$, and P_j are the probabilities of surviving the remaining years through j (1981 in this study). The square root of P_i is an excellent estimate of the probability of surviving the year in which the case was lost to follow-up, since on the average, patients were assumed to be lost to follow-up in the middle of the year. The sum of CP for each case lost to follow-up was equal to the total estimated number of cases lost to follow-up in which the patient survived to January 1, 1982.

RESULTS

Age-Adjusted Prevalence Rates

The prevalence rate among males for all sites of cancer combined was 1789 per 100,000 (Table 1).

Table 1. Age-Adjusted (to the 1980 U.S. Population) Prevalence Rates of Cancer per 100,000 in Connecticut on January 1, 1982.

Site or Type of Cancer	Sex	
	Male	Female
All	1789.0	2221.6
Buccal cavity/pharynx	107.7	45.5
Stomach	32.2	17.8
Colon	249.3	224.1
Rectum	144.7	97.6
Pancreas	7.5	5.7
Larynx	81.4	13.6
Lung	134.8	61.2
Melanoma (skin)	80.6	77.0
Breast	—	847.6
Cervix uteri	—	138.4
Corpus uteri	—	273.0
Ovary	—	92.7
Prostate	372.3	—
Testis	53.6	—
Bladder	232.6	62.5
Kidney	60.8	31.4
Brain and central nervous system	23.1	18.0
Thyroid	23.7	67.7
Hodgkin's disease	38.7	32.9
Non-Hodgkin's lymphoma	62.2	49.3
Leukemia	40.6	26.9

Prostate cancer was the most prevalent malignant disease among males (372 per 100,000); it was followed by colon cancer (249 per 100,000), bladder cancer (233 per 100,000), rectal cancer (145 per 100,000), and lung cancer (135 per 100,000). The observed ordering of prevalent sites was a function of the combined effects of incidence and survival. For example, although lung cancer was the most common incident cancer among males,[6] it was the fifth most prevalent cancer because of the relatively low survival rate among persons with the disease.

Among females, the prevalence rate for all sites combined was 2222 per 100,000. Breast cancer was the most prevalent malignant disease, with a rate (848 per 100,000) that was more than twice that of prostate cancer in males. The next four sites in decreasing order were the corpus uteri (273 per 100,000), the colon (224 per 100,000), the cervix (138 per 100,000), and the rectum (98 per 100,000). Breast cancer was ranked first in incidence and was also the most prevalent cancer because of the relatively favorable survival rate.

The cancer incidence rate in Connecticut from 1978 through 1981 was almost one third higher in males than in females (463 vs. 342 per 100,000, age-adjusted to the 1980 U.S. population),[6] yet the prevalence rate for all sites combined was about 25 percent higher in females than in males. Better survival among persons with cancers that are common in women accounted for this finding.

Age-Specific Prevalence Rates

Although the age-adjusted rates were useful summary measures, age-specific rates revealed a more complete pattern of cancer prevalence (Tables 2 and 3). Through age 29, the prevalence rates for all sites combined were similar for males and females (Fig. 1). From ages 30 through 59, the prevalence rates in women were approximately twice the rates in men, reflecting the large contribution of breast and gynecologic cancer to the rates among women. After age 70, the rates among men were higher, partly because of the high rates of prostate and bladder cancer in elderly men. The prevalence rates among women for all sites combined ranged from 1170 per 100,000 among those 30 to 49 years old to 10,635 per 100,000 among those over 70. In men, the rates for all sites combined increased from 598 per 100,000 among those 30 to 49 years old to 11,810 per 100,000 among those over 70. In other words, 11 percent of the women and 12 percent of the men over 70 had a diagnosis of cancer.

The prevalence of prostate cancer increased dramatically in older men; about 0.9 percent of men 60 to 69 years old, as compared with 3.7 percent of those over 70, had previously received a diagnosis of prostate cancer. The prevalence of breast cancer in women increased from 0.4 percent among those 30 to 49 to 2

Table 2. Age-Specific Prevalence Rates of Cancer per 100,000 among Males in Connecticut on January 1, 1982.

Site or Type of Cancer	Age Group					
	0–29	30–49	50–59	60–69	>70	Total*
All	134.4	597.6	2296.3	5380.3	11,809.7	1789.0
Buccal cavity/pharynx	2.6	32.6	196.5	390.2	608.3	107.7
Stomach	0.3	8.0	37.9	102.0	230.6	32.2
Colon	0.7	26.2	246.4	723.8	2,053.2	249.3
Rectum	0.3	13.4	161.1	477.3	1,123.2	144.7
Pancreas	0.0	2.1	12.6	26.1	46.1	7.5
Larynx	0.0	16.4	136.4	332.9	475.4	81.4
Lung	0.8	27.7	238.6	564.5	757.6	134.8
Melanoma (skin)	5.6	74.5	200.7	238.3	261.3	80.6
Prostate	0.1	2.6	129.2	906.3	3,696.8	372.3
Testis	19.1	95.3	101.6	93.8	42.8	53.6
Bladder	2.2	43.2	319.1	729.0	1,679.9	232.6
Kidney	6.6	21.1	101.6	208.5	332.7	60.8
Brain and central nervous system	19.1	26.2	26.4	36.5	20.9	23.1
Thyroid	4.4	32.4	52.9	57.3	49.4	23.7
Hodgkin's disease	25.3	70.7	40.9	35.0	29.6	38.7
Non-Hodgkin's lymphoma	8.9	37.3	126.2	198.1	261.3	62.2
Leukemia	16.5	13.4	40.3	114.7	203.1	40.6

*Age-adjusted to the 1980 U.S. population.

Table 3. Age-Specific Prevalence Rates of Cancer per 100,000 among Females in Connecticut on January 1, 1982.

Site or Type of Cancer	Age Group					
	0–29	30–49	50–59	60–69	>70	total*
All	142.7	1169.8	4538.0	7530.7	10,635.0	2221.6
Buccal cavity/pharynx	2.8	24.1	96.3	165.1	198.8	45.5
Stomach	0.1	4.6	17.2	57.3	139.9	17.8
Colon	1.7	31.8	251.2	662.8	1,887.7	224.1
Rectum	0.1	14.1	124.0	350.3	722.9	97.6
Pancreas	0.0	1.2	10.0	19.5	38.0	5.7
Larynx	0.1	6.6	33.2	59.9	46.2	13.6
Lung	0.3	24.5	143.3	272.2	233.6	61.2
Melanoma (skin)	9.5	102.5	184.3	188.4	183.6	77.0
Breast	4.2	413.3	2067.3	2983.4	3,888.7	847.6
Cervix uteri	8.1	120.8	286.6	447.4	528.0	138.4
Corpus uteri	0.7	58.3	542.8	1234.9	1,342.0	273.0
Ovary	8.5	62.4	227.4	312.5	329.2	92.7
Bladder	1.3	22.1	101.3	201.0	410.8	62.5
Kidney	8.7	11.9	45.9	94.5	158.3	31.4
Brain and central nervous system	15.7	19.7	24.9	22.7	15.8	18.0
Thyroid	14.6	112.7	146.6	129.2	107.0	67.7
Hodgkin's disease	24.1	53.0	40.9	27.7	27.2	32.9
Non-Hodgkin's lymphoma	5.2	27.5	100.7	172.0	210.2	49.3
Leukemia	13.4	10.0	27.1	65.5	129.8	26.9

*Age-adjusted to the 1980 U.S. population.

percent among those 50 to 59 to nearly 3.9 percent among those over 70.

Discussion

Incidence, mortality, and survival rates are the principal epidemiologic measures used to estimate the magnitude of the cancer problem in the United States.[6-11] Prevalence is an important measure since it reflects the effects of both incidence and survival, thereby providing an illustration of the magnitude of the problem in one measure. Reliance on incidence rates results in overlooking the fact that 38 percent of patients with cancer survive at least five years after diagnosis.[10] By counting all living persons with a history of cancer, prevalence determinations summarize the total known disease burden in the population.

We did not attempt to estimate the prevalence of undetected cancer. Rather, the definition of prevalence used resulted in the selection of all living patients with a known history of cancer who had at one time sought treatment. No distinction between patients who were "cured" and "not cured" was made, because that determination is frequently ambiguous and because survivors of cancer may continue to have effects of the disease. Recently, Mullan[12] called attention to the latter phenomenon. Problems related to second neoplasms, disease recurrence, disability, employment, insurance, and reproduction may linger long after the treatment ends. The consequences of cancer and its treatment are sufficiently serious to warrant the use of the definition of prevalence that we employed.

About 2 percent of the population of Connecticut in 1982 had a history of cancer. This figure is deceptively low because of the low prevalence of cancer among young people. In the population over age 70, however, approximately 12 percent of men and 11 percent of women had a history of cancer. Application of the age-specific prevalence rates to the U.S. population in 1986[13] results in an estimate of about 5 million prevalent cases. Use of the projected U.S. populations for the years 2000 and 2030[13] yields prevalence estimates of 6.2 and 9.6 million patients, respectively, reflecting the anticipated aging of the U.S. population. The economic cost of neoplasia in the United States was estimated to be about $51 billion in 1980, about 11 percent of the total cost of illnesses of all types.[14] As the prevalence of cancer increases, the costs to society will also increase.

These prevalence estimates and projections for the United States assume stable incidence and survival patterns and require several qualifications. First, it can be argued that because of the excellent ascertainment of deaths by the registry, ap-

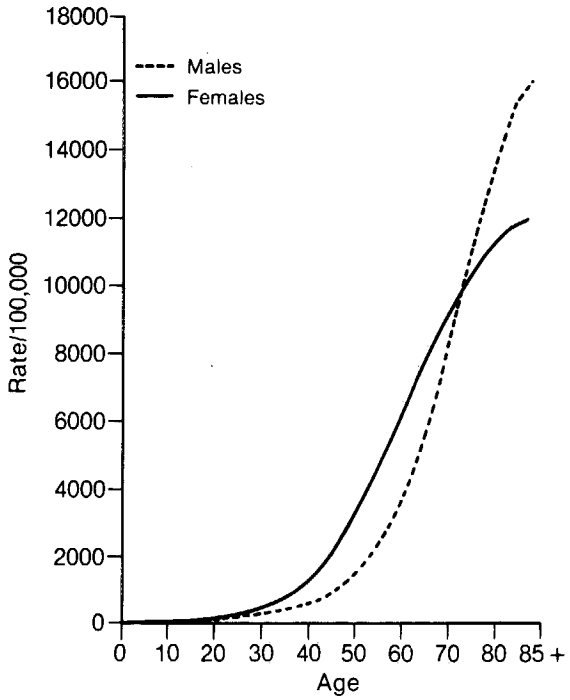

Figure 1. Age-Specific Prevalence Rates of Cancer in Connecticut on January 1, 1982.
The rates are for all sites of cancer combined.

plying the usual life-table assumption that cases lost to follow-up have the same survival rate as the cohort in general may result in an overestimate of the number of deaths in the group that was lost to follow-up.[10,15] Using data from the SEER program, Ries et al.[10] computed cancer survival rates by assuming that all patients lost to follow-up survived until the end of the study period, and they demonstrated an increase in survival of about three percentage points. Therefore, the prevalence rates presented here may underestimate the true prevalence of cancer by a small amount. Second, because the racial and ethnic composition of Connecticut is different from that of the United States as a whole and because there are marked contrasts in both incidence and survival patterns between blacks and whites and between ethnic groups,[10,11,16,17] prevalence rates for the entire country cannot be assumed to mirror those in Connecticut. Third, we recognize that migration out of the state tended to increase the number of cases lost to follow-up. However, since the total number of cases lost to follow-up represented only 6.9 percent of the total patient series, the effect of migration on prevalence estimates was probably very small.

The method employed in this analysis can be adapted to any long-term population-based tumor registry. The Connecticut Tumor Registry provided 47 years of records of newly diagnosed cases for this analysis. We repeated the calculations using fewer years to ascertain the number of years of data necessary to obtain reliable prevalence estimates. Although 27 years (1955 through 1981) of data resulted in a prevalence count that was about 95 percent that of the 47-year period, 17 years of data (1965 through 1981) resulted in a prevalence that was only 84 percent of the total. These results should serve as guidelines to researchers who wish to calculate cancer prevalence in other regions of the country.

The high prevalence of cancer can be viewed in a positive sense: the successes in treatment have resulted in improved survival among patients with cancer and an increase in the prevalence of cancer. With the better survival, knowledge of the physical effects of cancer has greatly expanded, and the consequences of the disease and its treatment are known to have long-term effects on virtually every organ system in the body.[18-20] More recent research has demonstrated a wide range of psychosocial consequences of cancer — from difficulties in obtaining health insurance[21] and employment to generalized feelings of anxiety and depression.[18] Frequently, both physical and psychosocial disability can be prevented or at least ameliorated if the potential for it is recognized early by physicians.[1] Because the quality of life among survivors is an increasingly important issue,[12] systematic long-term follow-up is essential to identify new late effects and to intervene early in the prevention of disability.

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